it had proposed in an unshared environment. This could lead to some or all CDMA MSS systems becoming uneconomically viable. Support of this sharing approach is provided in the Commission's spectrum sharing proposal in this NPRM which advocates spectrum sharing among MSS systems employing CDMA which can only be economically viable if the pfd limits are slightly increased as shown in the capacity charts developed during the NRM. With this implied support of the Commission, the CDMA MSS operators have sought an increase in the allowable pfd limits within the 2483.5-2500 MHz band.

At the Jan/Feb 1994 international meeting in Geneva of ITU-R Task Group (TG) 2/2 concerned with Frequency Sharing Criteria within the Range 1-3 GHz, several papers were introduced which supported increasing the allowable pfd limits for the 2483.5-2500 MHz band. One[7] of these papers specifically presented the results of an analysis of the effects of a particular MSS system's emissions (in essence, this MSS system is GLOBALSTAR which is also known as LEO D in the ITU-R glossary of MSS systems) upon the reference analog relay route used in ITU-R analyses. The analysis employed is based upon a computer simulation and methodology described in a ITU-R Draft New Recommendation[8] which accounts for the probable interference to both analog and digital systems. This Draft New Recommendation (Document 9/178-E) was partly developed by Commission personnel. Also Document 9/178-E is currently being presented for approval to Study Group 9 which is concerned with the Fixed Service. The computer simulation analysis described in Document 2-2/27-E was performed by a Commission employee and the results were interpreted by LQP. The interpretation of these results indicate that the analog relay systems can operate and meet the requirements of ITU-R Rec. 357 even with a considerable increase in pfd. Instead of RR 2566, both Document 2-2/27-E and LQP propose the following pfd emission mask for each LEO/MSS satellite when sharing the 2483.5-2500 MHz spectrum with other CDMA MSS operators:

-149 dBW/m^2/4 kHz	for $0 \leq \phi \leq 5$ degrees,
$-149 + 0.65\,(\phi\text{-}5)$ dBW/m^2/4 kHz	for $5 < \phi \leq 25$ degrees, and
-136 dBW/m^2/4 kHz	for $25 < \phi \leq 90$ degrees,

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7 See Attachment 2, Document 2-2/27-E, 25 January 1994, Simulation of Interference into Analog Radio-Relay Routes from Low-Earth Orbiting Satellites of the LEO D Mobile-Satellite Service System.

8 Document 9/178-E, 13 October 1993, Determination of the Criteria to Protect Fixed Service Receivers from the Emissions of Space Stations Operating in Non-Geostationary Orbits in Shared Frequency Bands, Source Document 9D/TEMP/31(Rev.1)-E.

where ϕ is the angle of arrival from the satellite at any point on the surface of the Earth.

Various TG 2/2 and WP 9D contributions have shown that digital systems are somewhat less robust than analog systems. The pfd limits in the Radio Regulations are designed to protect analog systems. Since it is more likely that only analog systems are deployed in the band allocated by WARC-92, a question of principle arises as to whether more sensitive digital systems which may or may not be introduced into the new bands should be used as the sole determinate of pfd limits. LQP believes that it would be more practical to weight the pfd limits on the side of protecting the analog systems. In the preceding paragraph it has been shown that these analog systems can operate and meet the requirements of ITU-R Rec. 357 even with a considerable increase in PFD. Based upon a recent contribution[9] to US WP 9D, it has been shown that a relative small increase in eirp of the digital radio-relay transmitting station will restore the availability of the digital system. For the GLOBALSTAR system, this represents an eirp increase of less than 2 dB, or a decrease in the fade margin of this same amount out of typical fade margins in the 30 to 60 dB range, or a reduction of 3-6%. Also the probability of a fade requiring the full fade margin occurring at the same time that a GLOBALSTAR satellite would be within the main beam of a FS antenna should be extremely low. Given the small and dwindling number of grandfathered fixed systems in operation in this band as shown in paragraph 2.3.1.2, it does not seem practical to adopt unnecessary and punitive protection requirements to protect a small number of systems which may be using digital technology.

Also during the aforementioned ITU-R TG 2/2 meeting, a paper was introduced and modified to become a Working Document Toward a Draft New Recommendation[10] with the intent of specifying increased pfd trigger levels which would not require coordination. If these increased pfd levels were exceeded, an analysis similar to that used in Document 2-2/27-E for a specific MSS system would be performed to verify that the Fixed Service protection levels were not exceeded. If this protection could not be demonstrated then coordination would be required. The results of the GLOBALSTAR analysis in Document 2-2/27-E were included in output Document 2-2/TEMP/1(Rev.5)-E. This output document will be discussed in subsequent TG 2-2 meetings to develop a final position on the coordination methodology for sharing with fixed microwave systems. LQP supports the Commission's acceptance of the NRM Committee's finding

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[9] USWP 9D-1(Rev.1), March 8, 1994, Some Simulation Results for Determining Power Flux Density Limits on Emissions from Low Earth Orbiting Satellites into Digital Terrestrial Receivers.

[10] Document 2-2/TEMP/1(Rev.5)-E, 8 February 1994, Non-GSO MSS Satellite Transmissions Interfering to Fixed Service Networks.

that interference problems between terrestrial fixed services and MSS downlinks operating in excess of the prescribed pfd limits may be settled through the coordination process.

2.3.1.2 Current Status of Fixed Service Stations in the 2483.5-2500 MHz Band

Citing the 1985 RDSS Allocation Order[11], Paragraph 60 of the NPRM states that:

> Over 700 fixed terrestrial stations, including temporary fixed transportable stations, are licensed and operating in the U.S. in the 2483.5-2500 MHz band. These stations are primarily used as links in microwave relay systems serving petroleum companies and as broadcast auxiliary links.

In 1985 the Commission grandfathered the stations licensed at the time, and prohibited any further terrestrial licensing in this band. This prohibition is embodied in the Commission's rules. Section 2.106, Footnote NG (Non-Government) 147, reads:

> Stations in the broadcast auxiliary service and private radio services licensed as of July 25, 1985, or on a subsequent date following as a result of submitting an application for a license on or before July 23, 1985, may continue to operate on a primary basis with the radio determination-satellite service.

But only 30% of these grandfathered systems are in operation today. The FCC's most recent Non-Government Frequency Master List, dated January 1994, lists a total of only 173 licensees in this band out of the reported 700 terrestrial systems. Four of those licensees are each authorized 20 units, and two licensees are each authorized two units. Therefore, there is a total of 251 licensed units in this band.

Of that number (251 licensed units), 207 are in mobile, transportable or temporary fixed service, while 44 are licensed for fixed operation. But not all of these licensed units are in constant, or even frequent use, in all parts of the country. For instance, based on information from the Frequency Advisory Committee responsible for the Philadelphia area, none of the 20 units shown as being licensed in that city are in use now.

A detailed inquiry of the other licensees would undoubtedly reveal that many of the 230 units are no longer in operation, especially in the smaller cities of the country

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[11] R&O, Gen. docket 84-689, FCC 388 (released September 13, 1985). Actually, this Allocation Order gives the specific number of such stations as 737.

where other frequencies subsequently allocated for these services are available, notably the 1990-2100 MHz band, the 12.7-13.2 GHz band, and the 18 GHz band.

In summary, although there were over 700 terrestrial licensees in the 2483.5 - 2500 MHz band in 1985, no more than 230 licensees, 30% of that number, remain. The characteristics of these remaining terrestrial systems are such that there will rarely be interference to them from MSS space station emissions, and the severity of that interference will be minimal. LQP, therefore, believes that it is not necessary at this time for the Commission to adopt any formal relocation policy for the incumbent microwave systems. Instead, the Commission should adopt rules that call for coordination if and when the specified pfd limits are exceeded.

2.3.2 Fixed Service above 2500 MHz

2.3.2.1 Interference from ITFS/ MMDS into MSS Mobile Earth Stations

This analysis reports on the interference potential from transmitters in the Instructional Television Fixed Service (ITFS) and Multi-channel Multipoint Distribution System (MMDS) into Mobile Earth Station (MES) receivers in the Mobile Satellite Services (MSS). ITFS television stations transmit within the band 2500 to 2690 MHz while the MSS MES's receive in the adjacent band 2483.5 to 2500 MHz. Therefore it was required to examine the possibility of interference from transmitters operating in the lowest frequency ITFS channel into MES receivers employing CDMA waveforms and operating in the top frequency channel of the MSS band. Interference from MSS to ITFS/MMDS was determined by the NRM to be negligible.

As demonstrated in the analysis in the following subsections, and by the supporting technical attachments, interference will be minimal from ITFS Channel A-1, which operates at 2500-2506 MHz, and is thus immediately above the MSS band. Therefore, the possibility of interference will be even less from all other ITFS channels, and from all MMDS stations (which have technical characteristics identical to those of ITFS), and which operate on frequencies above 2506 MHz.

The conclusion is that MES receivers will be able to operate up to 2500 MHz without interference from ITFS transmitters. There might occur a few exceptional situations where a MES could experience ITFS interference, but in that case the GLOBALSTAR system has the capability to reassign the user channel frequency to a channel experiencing less interference if required. Furthermore, it is not necessary to require any changes or modifications to the ITFS spectrum assignments or equipment.

2.3.2.2 ITFS/ MES Interference Analysis

The Commission has noted (NPRM, para. 64) that "the most serious interference problem to MSS downlinks . . . appear to stem from ITFS operations in the adjacent 2500-2506 MHz band." The following analysis shows that this interference situation is much less severe than indicated in the NRM Report. Therefore, there is no reason to create a guardband in the upper part of the 2483.5-2500 MHz MSS band.

The number of ITFS stations licensed to operate on channel A1 (2500-2506 MHz) is approximately 260 throughout the United States, whereas only about 200 are now in operation. The coverage areas of ITFS channel A1 stations are typically within urban environments which are now served (or are projected to be served) by terrestrial cellular radio systems. Dual-mode MES's[12] will typically not be operating in the MSS band in these areas, in which case ITFS interference will not be an issue.

However, even if ITFS radiation on channel 1 is encountered, the MES unit will not be seriously affected. The FCC Rules, "¶ 74.935 Power limitations" restrict the maximum operating radiated power from the ITFS transmitting antennas. ITFS transmitting antennas are typically of either of two types:

"Broadcast" type antennas, which are intended to serve ITFS receivers throughout a metropolitan area, pose a potential source of interference into MSS receivers. This type antenna pattern has a narrow beamwidth in the vertical plane to provide adequate signal levels to all ITFS receivers with the coverage area. The transmitting antenna has a slight downward tilt to provide the greatest signal strength toward those ITFS receivers at the far limits of the coverage area. The interference potential determined by LQP measurements made in the San Francisco Bay Area indicated a received isotropic power (RIP) (the level received by an isotropic antenna) of the ITFS visual carrier which varies between -70 to -80 dBm.[13] At short distances (less then 2 miles) from the ITFS antenna site), the RIP can be as great as -60 dBm, but in the San Francisco Bay Area, the ITFS transmitting sites are often positioned on high hill tops overlooking their coverage area where the areas surrounding the sites are relatively unpopulated.

Up to 28% of the ITFS transmitting antennas are of the "directional" type antennas

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[12] Dual mode MES units are capable of operating in either a terrestrial mobile system (cellular) or in a mobile-satellite system.

[13] See Attachment 3, "Field Measurements of ITFS Interference in the San Francisco Bay Area"

intended to relay service to a single, specific distant location, for subsequent re-distribution from that site. Focused beams of this type antenna would present the possibility of interference at greater distances from the ITFS transmitting site but only within the narrow beamwidth of the antenna.

Typically, ITFS stations transmit at power levels sufficient to supply adequate signal levels to ITFS receivers within the coverage area, transmit levels which are typically less-costly to operate and lower than that permitted by the FCC.

The FCC Rules, "¶ 74.936 Emissions and bandwidth" restrict the bandedge and the out-of-band emission levels of the ITFS transmitters. These out-of-band (i.e., below channel A1 bandedge) emission limits would be within the MES receiver bandwidth operating in the highest MSS channel. The FCC restrictions are -38 dBc at the band edge and -60 dBc at 1 MHz and below the lower bandedge relative to the ITFS visual carrier level.

The permitted ITFS out-of-band emissions are of sufficiently low level that considering the RIP levels measured throughout the ITFS coverage area, these levels will not present an interference problem to MSS MES receivers employing wideband CDMA wave forms. The maximum tolerable interference level of a MSS MES receiver employing a wideband (e.g., 1.25 MHz) CDMA waveform and a maximum power control of 10 dB is forecasted to be -106 dBm. This is higher than the projected ITFS bandedge RIP of -108 dBm, which is 38 dB below the visual carrier maximum measured RIP of -70 dBm. For MES receivers operating in all except the top MSS frequency channel, projected ITFS interference should be no greater than -130 dBm, well below the -106 dBm tolerated by the MES receiver. CDMA applicant has proposed a spreading bandwidth smaller than 1.25 MHz. Therefore, the analysis presented here is applicable to all proposed CDMA systems as updated at the NRM.

A potential for interference does not exist from the ITFS visual carrier itself. The ITFS carrier frequency will be offset approximately 1.9 MHz above the center of the highest MSS channel and 1.3 MHz from the upper band edge of the top GLOBALSTAR RF channel number 13 if operated right at the 2500 MHz bandedge. The selectivity of the MSS receiver (i.e., its ability to attenuate the ITFS carrier before it can cause interference) is sufficient to reduce the ITFS carrier level to approximately the same level as the ITFS transmitter out-of-band emissions. The MES receiver selectivity is projected to be (coincidentally) 38 dB at 1.9 MHz from the center of the highest MSS channel. Therefore, the ITFS carrier poses no greater interference potential than the out-of-band emissions, which will not present a problem.

2.3.2.3 ITFS Interference Conclusions

The ITFS transmitters will be predominately located in urban areas were terrestrial cellular radio will provide service to dual-mode MSS MES receivers, and in which case ITFS interference is not an issue.

For those exceptional cases where MSS operation is required in the highest MSS channel within ITFS coverage areas, an MES employing a wideband CDMA waveform will operate satisfactorily in all but a few extreme situations. This is because the ITFS transmitter out-of-band emission limits will be below the maximum level of interference tolerated by a MESs receiver over the ITFS coverage area. MES receiver selectivity will reject the ITFS visual carrier level to be also below the maximum level of interference tolerated by a MES receiver. MES operating in all lower MSS channels (1 to 12) will not experience ITFS interference. Therefore, there is no need to employ spectrum inefficient guard bands or to modify ITFS transmitters with sharper filters in order to provide MSS operation up to 2500 MHz.

2.3.3 Industrial, Scientific, and Medical (ISM) Emissions at 2400-2500 MHz

2.3.3.1 ISM General

There is insignificant potential for interference from emitters in the Industrial-Scientific-Medical (ISM) frequency band into Mobile Earth Station (MES) receivers of the Mobile Satellite Services (MSS). The ISM band is 2400 to 2500 MHz while the MES's receive the MSS downlink in the upper end of the ISM band from 2483.5 to 2500 MHz.

At the NRM, there was no consensus reached on ISM interference potential. ISM emissions were identified as being a potential problem. However, at that time, data submitted by some parties was used to generate an inaccurate model of the situation, data which was inapplicable to MSS downlinks employing a wideband CDMA waveform.

The conclusion of a LQP measurement campaign, which evaluated ISM emissions in several environments, is that MES receivers will be able to operate throughout the MSS band, down to 2483.5 MHz, without appreciable interference from ISM emitters. There may occur a small fraction of situations where a MES could experience ISM interference, but in that case other network operational arrangements could be made to provide service.

2.3.3.2 ISM Background

ISM devices, including household microwave ovens, are authorized to transmit (intentionally) or emit (unintentionally) into the same frequency band as is allocated for the MSS S-band downlinks to mobile earth station (MES) receivers. This potential concern was described using data contained in a NTIA report[14], data which is inapplicable to the MSS downlink situation and was erroneously used to generate models of microwave oven interference. The data in the NTIA report is inadequate for the present purpose for several reasons:

- The geometry envisioned in the NTIA report is for MSS uplink. That uplink model envisioned a multitude of ovens whose signals would be received by the satellite at a very remote distance, and therefore the oven emissions could be considered to be aggregated into a single noise source located in the center of a city. Conversely, the geometry for the GLOBALSTAR is for MSS *downlinks*, a situation which places the MES receivers on the ground in the midst of the ovens at short range, many of which will be blocked and shadowed.

- The propagation model in the NTIA report is for *clear line-of-sight* satellite uplinks, where the propagation model for an ISM emitter to a MES receiver needs to be for ground-level-to-ground-level propagation with significant impairments from obstructions caused by buildings and trees.

- The 2300 to 2430 MHz range of frequencies examined by NTIA does not include the frequency range allocated for MSS downlinks. The NTIA report does include the tantalizing statement (on Page 2-2), "The emission levels above 2450 MHz fall off much more rapidly, dropping sharply above 2480 MHz for all ovens tested."

- ISM (Industrial, Scientific, and Medical) includes other emitters besides microwave ovens. Constructing a ISM model on only an aggregate of microwave ovens, which predominate in residential areas, may not produce a realistic description of the entire ISM environment.

- The NTIA data collected for the MSS band was taken with a spectrum analyzer in the "peak hold" mode which produces a worst-case envelope

[14] NTIA TM-92-154, "Accommodation of Broadcast Satellite (Sound) and Mobile Satellite Services in the 2300-2450 MHz Band", U.S. Department of Commerce, January 1992.

display of the strongest signal ever encountered at each frequency over a long period of time. Such a display is not indicative of the real-time ISM interference potential to a CDMA receiver employing digital signal processing techniques such as data interleaving.

Because all the necessary parameters are not available for building an accurate statistical model of the situation, it was determined that field measurements would be required in various types of environments. LQP has sponsored a detailed ISM measurement campaign in urban/suburban and rural environments. The results are reported herein.

2.3.3.3 ISM Equipment Spectral Emissions in the 2400-2500 MHz Band

The overwhelming majority of devices of Industrial, Scientific, and Medical (ISM) devices in the band 2400 - 2500 MHz are residential and commercial microwave ovens with powers below 1000 watts.

The FCC rules allocates Industrial, Scientific, and Medical (ISM) devices to the frequency "2450 MHz +/-50 MHz." That would imply that emissions from ISM devices are equally likely to be found in the 100 MHz band from 2400-2500 MHz. However, a combination of the actual wording of the allocation cited above, and the emission characteristics of these devices, have resulted in concentration of the center frequency of ovens around 2450 MHz. with sidebands extending some 30 to 35 MHz on either side.

Because of the FCC requirement to confine emissions within 50 MHz of the center frequency, 2450 MHz, and the fact that the carrier frequency of ovens may drift during their lifetime, oven manufacturers center their production at 2450 MHz. Consequently, there will be less interference to MESs which will be operating in the upper segment of the band, 2483.5 - 2500 MHz, than there would be if emissions from these devices were distributed uniformly throughout the entire 100 MHz-wide band.

This concentration has been confirmed by measurements made recently by LQP in a densely populated residential, industrial and commercial region of California. Measurements were made in a vehicle equipped with test equipment as it was driven from LQP facilities in Palo Alto in a large circle around San Francisco Bay, passing through or near major population, industrial, and commercial centers. The details of these measurements are given in Attachment 4[15] and a discussion of the findings is given

[15] See Attachment 4, "Field Measurements of ISM interference in the San Francisco Bay Area".

in Attachment 5.[16]

The conclusion that can be drawn from these measurements is that frequencies at the upper end of the ISM band, that is, the band segment 2483.5-2500 MHz to be used for MSS space-to-Earth transmissions to be received at MESs will be relatively interference-free. Furthermore, even in case of an MES being operated in a vehicle driving past an operating microwave oven, little or no interference may be caused because of the limited number of high-level pulses from the oven that may be received. In the rare case of interference caused say, by the fixed operation of an MES in the immediate vicinity of an operating oven, operational techniques can be employed to detect the presence of interference and to switch the connection to a different frequency, as discussed further in Attachment 5. Even several such frequency changes could be made automatically, as necessary, during a connection without being noticed by the user.

2.3.3.4 ISM Field Measurements and Laboratory Evaluation

A van was equipped with (1) a roof-mounted, omni-directional in azimuth antenna, (2) a low-noise preamplifier adjacent to the antenna, (3) a spectrum analyzer as a receiver, and (4) a portable personal computer as a controller and data recorder. Results of the field tests were fed into a laboratory simulation of this environmental data into an MES so that evaluations of the situation could be performed in controlled, repeatable tests.

Measurements were made throughout the San Francisco Bay metropolitan area, which is worse than a typical concentration of ISM emitters because of the population concentration between the San Francisco Bay and its surrounding hills, as well as the possibility of clear over-the-water propagation from multiple emitters across the Bay. Sequences of time samples were taken while traveling adjacent to urban industrial and residential areas bordering the metropolitan freeways. Each sample was 100 milliseconds in duration (about 9 feet at freeway speeds) and the sequence was repeated every 17 seconds (1500 feet at freeway speeds). The spectrum analyzer bandwidth was set to 1 MHz, approximating the wideband CDMA receiver bandwidth.

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[16] See Attachment 5, "Discussion of ISM Measurements in the San Francisco Bay Area".

Results show that the interference level falls off with increasing frequency above 2450 MHz, making the lowest MSS frequency of 2483.5 MHz typically the worst affected MSS channel. Therefore for the lowest MSS channel, each 100 millisecond record was examined for the peak ISM power level of the record. Sorting an entire sequence of records by order of the peak power level encountered provides a statistical picture of the ISM environment.

As an example, examining two ensembles of 214 (one hour) and 370 (1-3/4 hours) records taken of the lowest MSS channel after being sorted, it is observed the peak power levels fall off rapidly from their maximums. The maximum peak encountered is that value which would be recorded as "peak hold" in the prior NTIA report and is observed to be a rare event.

The ISM interference was observed to be pulsed in nature, often with very low duty cycles, but sometimes with a noticeable 60 Hz pattern and higher duty cycles representative of individual microwave ovens. Laboratory measurements performed by LQP with simulated ISM emissions fed into wideband CDMA receivers employing data interleaving have identified the interference mechanism as being primarily dependent on duty cycle (percentage of time above the total noise level). That is, once the ISM interference produces a pulse of level comparable to the total received noise level (system noise plus receiver thermal noise), ISM pulses can damage portions of the received data stream. But with data interleaving, the data can be reconstructed to a degree inversely proportional to the duty cycle of the interference.

Of the 214 and 370 recorded sequences in the urban environment, only approximately 3 records (0.5%) exceeded a level which would produce unacceptable signal quality for some period of time. Another (1.5%) would exceed a level which would cause aural signal quality degradation. All other recorded sequences (98%) would produce no noticeable degradation. A rough correlation is noted where those ISM records having the highest peak levels generally produced the worst interference. Peak interference levels up to 20 dB greater than the total received noise level were not observed to produce appreciable aural signal quality degradation.

The ISM emission levels evaluated above are expected to be typical of those within urban environments. Significantly lower levels have been measured in suburban and rural environments. A subsequent campaign of rural environments adjacent to freeways north of San Francisco measured peak levels typically 15 dB lower than those encountered in the urban environment. The interference levels measured are too low to evaluate with respect to duty cycle, producing too few measurable records.

2.3.3.5 Conclusions on Interference from ISM

Urban environments are now served (or are projected to be served) by terrestrial cellular radio systems. Dual-mode MES's will typically not be operating in the MSS band in these areas, in which cases urban ISM interference will not be an issue. However, MSS MES receivers could be operated within an urban environment in 98% of the instances recorded with full signal quality, and the signals would effectively be usable 99.5% of the time. The very few instances of high level ISM interference experienced such as when within 50 feet of a typical microwave oven, or inside of urban areas near large ISM equipment installations, could be addressed by the user moving to a new location. Therefore, there is no need to employ spectrum inefficient guardbands or to modify ISM emitters with filters or frequency stability devices in order to provide MSS operation across the entire 2483.5-2500 MHz band.

SECTION 3

3.0 Feeder Links

3.1.0 Summary

LQP makes the following recommendations to the Commission regarding feeder link spectrum for NGSO systems:

(1) Authorize MSS feeder links in several bands (C-, Ku, Ka-bands) for both uplinks and downlinks; both the spectrum below 15 GHz as required by LQP, and the Ka-band spectrum as sought by Motorola and TRW, are required to meet the LEO/MSS service requirements.

(2) Authorize Reverse Band Working (RBW) for the FSS allocations below 15 GHz for MSS feeder links.

(3) Allocate 200 MHz within the bands 6425 to 7075 MHz for LQP downlinks; it is preferred, at this time, to use the portion between 6875-7075 MHz.

(4) Allocate 200 MHz within the band 5000 to 5250 MHz for LQP uplinks.

(5) Support and work to redefine RR 2613 as stated in the NPRM.

(6) Support, and work to achieve the above recommendations, as co-primary allocations for MSS feeder links, at WRC-95.

(7) Support other C- and/or Ku-band allocations for MSS feeder links, in FSS bands with RBW, as identified by LPQ in this Section.

3.1.1 LEO/ MSS Feeder Link Requirements Below 15 GHz

LEO/MSS feeder links were not allocated at WRC-92 and the subject is on the agenda for the WRC-95 Conference. Several proposals are being put forward by many administrations including the United States. Three of the MSS applicants, including LQP, have sought assignment of feeder link spectrum at C-band frequencies. The NRM itself addressed the feasibility of feeder link allocations in FSS bands below and above 15 GHz. However, the NRM did not address the reverse-band working concept which is being considered by LQP and others for feeder link operations below 15 GHz. The Reverse Band Working concept involves the operation of an MSS feeder link in a direction opposite to the FSS allocation. As the analysis in this section will demonstrate, there is ample proof that it is technically feasible to operate MSS feeder links in FSS spectrum blocks below 15 GHz (in C-and Ku-band allocations) using Reverse Band Working (RBW).

GLOBALSTAR proposes that C-band feeder links be allocated for the following reasons:

(1) 200 MHz in each direction for frequency reuse as proposed by LQP.

(2) Feeder links below 15 GHz are required for LEO (less than 2000 km altitude) operations, due to wide-area coverage feeder link antennas necessary for utilization of conventional repeater satellite designs such as the one proposed by LQP; Motorola can use directed beams on the satellite and locate its feeder link earth stations in areas which have low rainfall, due to the use of inter-satellite links; therefore, they can use frequencies above 15 GHz (Ka-band), but at a much higher system cost.

(3) The satellite-power required to combat rain attenuation at Ka-band for a conventional repeater design as employed in GLOBALSTAR, is impractical.

The basic concept is to use under-utilized FSS bands in the reverse-band mode.

Sharing with the Fixed Satellite Service is accomplished by Reverse Band Working (RBW). Satellite-to-satellite interference has been analyzed and proven to not cause degradation of performance. FSS earth stations and MSS feeder link earth stations are coordinated by utilizing standard uplink coordination procedures, and by utilizing site selection, RF shielding, terrain blocking, and other mitigation techniques.

Sharing with terrestrial microwave services is accomplished by low Power Flux Densities (PFD) in the MSS downlinks, and by feeder link earth station and other standard mitigating techniques on the uplinks.

The attachments 6 through 9 and 12 provide detailed studies on the feasibility of RBW.

As discussed in this report, spectrum allocations for LEO/MSS feeder links will be addressed at WRC-95. However, the Commission must authorize feeder links for LEO/MSS licensees prior to WRC-95. The Commission has in the past made such authorizations (for example, in the 12 GHz Direct Broadcast Satellite Proceedings in 1983). The Commission took several decisions on licensing and operational parameters of DBS systems prior to the Region 2 Broadcasting Satellite Conference (RARC-83); however, the 18 GHz DBS feeder link issue was not finalized until the 1985 Space WARC Conference). In a similar manner, the Commission should proceed with

LEO/MSS licensing including feeder link assignments.

3.2 LEO/ GSO Sharing

3.2.0 Introduction

NGSO/MSS feeder links are currently required in FSS allocations. Co-directional operation of NGSO/MSS feeder links with FSS/GSO networks give rise to the following four interference modes:

- NGSO/MSS satellite feeder link downlink into GSO/FSS earth station
- NGSO/MSS feeder link earth station uplink into GSO/FSS satellite receiver
- GSO/FSS satellite downlink into NGSO/MSS feeder link earth station
- GSO/FSS earth station uplink into NGSO/MSS satellite receiver.

Studies conducted by Working Party 4A (Reference: ITU-R 4A/TEMP/182, October 1993) have indicated that there could be significant technical and operational difficulties associated with the four interference cases identified above when NGSO/MSS feeder links operate co-directionally with GSO/FSS systems. In the FSS allotment bands and extension bands, there still could exist reasonable probability of satisfactory co-directional operations due to lighter usage of these bands. ITU-R Study Groups identified the need for studies, in Question 206/4, to address the need for reverse-band working (RBW) as a possible means to facilitate the operation of NGSO/MSS feeder links in FSS allocations. RBW results in the interference scenarios:

- NGSO/MSS satellite feeder link downlink into GSO/FSS satellite receiver
- GSO/FSS satellite downlink into NGSO/MSS satellite receiver
- GSO/FSS earth station uplink into NGSO/MSS feeder link earth station receiver
- NGSO/MSS feeder link earth station uplink into GSO/FSS earth station receiver

3.2.1 LEO/ GEO Co-Directional Sharing

Analyses conducted to date are inconclusive about the prospects of co-directional sharing between GSO/FSS and NGSO/MSS systems. As mentioned by the Commission

(NPRM, Para. 72), the NRM Committee, in its report, is optimistic that the interference caused by antenna beam coupling between NGSO/MSS satellite downlinks and GSO/FSS earth station receivers could be reduced to satisfactory levels through a variety of coordination procedures, and balanced sharing principles. However, ITU-R 4A/TEMP/182 report is generally pessimistic about co-directional sharing between GSO/FSS and NGSO/MSS systems. The report of the CEPT Project Team SE 18 (Reference: Frequency Sharing Implications of Feeder Links for Non-GSO MSS Networks in FSS Bands, dated February 1, 1994 - excerpts included in Attachment 6) concludes that :

> *" Unless the non-GSO/ MSS satellites and earth stations are equipped to implement RR 2613 to protect GSO/ FSS networks, and the non-regulatory equivalent of RR 2613 to protect their own networks,......, it is probable that frequency sharing by non-GSO/ MSS feeder links and GSO/ FSS networks will lead to unsatisfactory quality for both services"*

The CEPT conclusion is based on its analysis that co-directional operations result in shortfalls in meeting C/I objectives required to protect FSS and MSS signals. As an alternative to reliance on RR 2613, and to achieve satisfactory protection levels for both the NGSO/MSS and GSO/FSS systems, the CEPT report recommends reverse band working.

Conclusions on the feasibility of co-directional operation are still incomplete. For example, a recent study by Alcatel shows that the percentage of time of interference from NGSO/MSS feeder link uplink into a GSO satellite is about 2% and the average duration is about 35 seconds. The simulation was done utilizing 20 GSO satellites, the GLOBALSTAR constellation and a 8-degree cone of illumination from the MSS gateway antenna. Other studies may indeed show that with reasonable coordination procedures, co-directional sharing can be made possible. However, LQP is concerned that any co-directional allocations for NGSO/MSS feeder links may be permitted at the expense of extremely stringent RR 2613 stipulations. For this reason, LQP supports RBW as the primary means for NGSO/MSS feeder link operations, particularly in the FSS bands below 15 GHz.

3.2.2 Reverse Band Working (RBW) in FSS Bands for MSS Feeder Links

LQP's proposed use of reverse-band working will alleviate concerns about LEO satellite-to-GSO earth station and GSO satellite to MSS earth stations coupling, on the downlink. However, the risk of GSO-LEO earth station coupling is introduced. LQP believes that consideration of earth stations operating at a minimum elevation angle of 10° with highly directive antenna beams (typically 1° or less half-power beamwidth) means that coordination will be possible in less congested areas. With mitigation techniques and terrain blocking, coordination may be possible even in congested urban areas on a case-by-case basis. This is greatly enhanced by the fact that all of the proposed frequencies are outside the frequencies currently in use with GEO satellites.

As discussed earlier, the ITU-R document 4A/TEMP/182 supports RBW below 18 GHz for NGSO/MSS feeder link allocations in the FSS bands. The report concludes that: (a) for interference cases between NGSO and GSO satellites, the carrier-to-interference (C/I) levels are in all cases considered above the required C/I protection level for the wanted system; (b) that for interference between GSO and NGSO MSS earth stations, coordination distances are on the order of 100-300 km, and are not unreasonable within an Appendix 28 type coordination process. The report believes that in practice very few cases of unacceptable interference would occur even if the two earth stations are located closer together due to higher antenna elevation angles, azimuthal discrimination, terrain blocking, artificial shielding, and other mitigation techniques.

The report of the CEPT project team 18 (see Attachment 6 for key excerpts from this report) analyzes reverse -band working, in C, Ku, and Ka-band, and the conclusions therein support the findings of 4A/TEMP/182. The CEPT Study draws the following important conclusions:

- satellite-to satellite interference is unlikely to be a problem in RBW;
- sharing requirements could be met by restricting the operation of feeder earth station antennas to elevation angles above about 10 degrees, and no special features need to be incorporated in the satellites;
- while earth station-to-earth station coordination along the lines of RR Appendix 28 would be required, coordination distances would be modest provided the feeder stations were located at reasonable angles to the azimuth pointing directions of nearby GSO/FSS earth stations;
- due to extreme propagation conditions, RBW might create design difficulties above 18 GHz;
- MSS feeder link sharing with terrestrial FS services in the RBW bands is feasible;
- non-GSO/MSS feeder link satellite downlinks are unlikely to exceed the PFD limits prescribed by the ITU-R for the protection of the radio-relay terminals;
- interference to the non-GSO/MSS satellite receivers from FS transmitters

are unlikely to exceed, for significant portions of the time, single-entry criteria based on ITU-R Recommendations for digital FSS carriers;

- provided that the NGSO/MSS feeder link earth stations are sited with reasonable angular separations from the principal axes of nearby radio-relay terminals, then the interference will be within acceptable limits for 99.99% of the time for separation distances below about 150 km in the case of feeder link earth stations, and about 100 km in the case of terrestrial terminals. Site-shielding, terrain-blocking, and carrier-frequency planning will further improve the situation.

Other studies conducted on the impact of RBW further validate the feasibility of using this technique for NGSO/MSS feeder link operations in the FSS bands. Three recent studies can be referred to which demonstrate that the satellite-to-satellite interference situation is within acceptable limits, and that RBW is a viable means of providing MSS feeder links in FSS frequency bands without the need for coordination (Attachment 7: Reverse Band Workng of NGSO/MSS Feeder Links in the 4500-4800 MHz and 6725-7025 MHz Allotment Bands, Document USTG 4/5-8, April 27, 1994; Attachment 8: Feasibility of Sharing FSS Allocations in RBW Mode for NGSO/MSS Feeder Links, Document USTG 4/5-5). Another study (Intermediate Circular Orbit to GSO Satellite Coupling Statistics for Reverse Band Working in the 4500-4800 MHz and 6725-7025 MHz Allotment Bands, Document USTG 4/5-10 Rev.1, April 27, 1994) concludes that it would be technically feasible to operate ICO/MSS feeder links in a RBW mode in the FSS allotment band without affecting the allotment plan band. Conclusions of these studies are generally applicable to all FSS allocations in the C- and Ku-bands below 15 GHz.

Another recent study conducted by LQP (Attachment 9: FSS Earth Station to MSS Land Earth Station Coordination Distances in Reverse Band Working Mode, USTG 4/5-4, April 29, 1994) analyzes the interference situation between the earth stations of the two satellite services. It uses GLOBALSTAR (LEO-D) parameters for the NGSO/MSS system, and uses INTELSAT digital and SCPC parameters for the GSO/FSS case. The report concludes as follows:

- coordination distances between FSS earth stations and LEO-D MSS feeder link Earth Stations are found to be about 100 km at Ka-band, 126 km at Ku-band, and 258 km at C-band;

- these are worst-case coordination distances, based on permissible short-term interference (0.002% of the time) assuming main-beam coupling of the two antennas, and in the presence of a short-term fade;

- by siting the MSS feeder link station to the north of the FSS earth stations in the northern hemisphere, and to the south in southern hemisphere, the coordination distances can be further reduced; and

- shielding, terrain-blocking, etc., will further improve the sharing situation;

There is some concern about a small risk of radiation interference between a LEO satellite and a GEO satellite along the earth limb, in either direction, when reverse-band is in use. LQP has studied this risk and found it to be negligible. Attachment 8 provides the analytical basis for this conclusion.

3.2.3 Sharing with Terrestrial Services

The FSS expansion band and allotment band frequencies are shared, on a co-primary basis, by terrestrial services (FS microwave, mobile, auxiliary broadcast,etc.). It is important to show that the NGSO/MSS feeder links operating in either co-directional or RBW mode in the FSS allocations, can share the spectrum with terrestrial services in those bands without causing unacceptable interference. As discussed earlier, the CEPT Report (Attachment 6) has studied this situation and concluded that NGSO/MSS feeder links can coexist with the terrestrial services. LQP conducted extensive sharing studies with Comsearch, Inc. in various FSS bands to determine the interference potential from NGSO/MSS feeder link uplinks and downlinks. It can be concluded that favorable sharing conditions prevail in all the frequency bands analyzed. There are concerns about the willingness of certain terrestrial users of some of these bands (4500-4800 MHz used by military systems, 5000-5250 MHz used by aviation community for microwave landing systems) to allow NGSO/MSS feeder links to share the spectrum despite adequate showing that such operations will not cause harmful interference. A detailed discussion on NGSO/MSS and FS sharing feasibility is provided in Section 3.3 and in Attachment 12.

3.2.4 LEO/ GEO-FSS Coordination

LQP agrees with the Commission's and NRM Committee's determination that sharing among LEO feeder links and GSO/FSS systems is feasible. The Commission and the Committee have proposed to codify a general obligation to coordinate in Part 25 of the Commission's rules. We agree with the Committee's suggestion that the U.S. should seek international agreement that RR 2613 will not be invoked to require a NGSO system to terminate operations unless the affected administrations have not reached agreement as to level of "accepted interference", and that the NGSO system is operating in excess of these accepted levels and/or the excess interference is caused by the failure of the NGSO system to maintain sufficient angular separation between satellites.

The Commission raises the potential for interference caused by antenna beam coupling between GSO earth stations and LEO satellites. As discussed in the NRM Committee Report, the coupling statistics could be reduced as much as needed through a variety of coordination procedures. The Committee suggested adoption of exclusionary options such as "geographic exclusion zones" and "dedicated frequency allocations to LEO feeder links" if the interference criteria and/or the sharing principles prove to be restrictive. LQP notes that the Committee did not conduct any analysis of the use of reverse band for LEO/MSS feeder links in the FSS allocations, and drew its conclusions strictly on co-directional sharing of the FSS allocations. As discussed earlier, reverse band working (RBW) alleviates or eliminates interference situations, thereby providing for easier coordination between GSO/FSS and LEO/MSS systems.

The U.S. position on the subject of the relevance and use of RR 2613 is described in Document 4A/244 submitted to WP 4A of ITU-R on September 22, 1993. This position is further amplified in a recent document, ITU-R TG 4/5-9: Development of GSO/Non-GSO Sharing Criteria under RR 2613. The U.S. administration takes the position that in order to implement RR 2613 in practice, discussions between affected administrations are required to the agreed levels of accepted interference between the GSO/FSS systems and the LEO/MSS systems operating in the same frequency bands. However, new GSO/FSS systems still have an obligation to protect existing primary LEO/MSS systems operating in the same band. The U.S. position is that RR 2613 uses the term "unacceptable interference", which is a term that cannot be defined without prior communication between affected administrations. LQP fully supports this viewpoint.

Several studies discussed earlier (Attachments 6 through 9 and 12) clearly demonstrate that RBW obviates the need for strict RR 2613 application for sharing between NGSO/MSS feeder links and GSO/FSS systems

INTELSAT has recently taken a position, in a letter to the ITU, that, "WRC-95 should unambiguously reaffirm the need for RR 2613 in order to safeguard the continued operation of FSS networks in the GSO." INTELSAT wants WRC-95 to require this position to be used at the examination stage for notices of non-GSO networks by the ITU-R prior to entry of these networks into the Master International Frequency Register. LQP believes that INTELSAT's position will have the effect of relegating LEO/MSS feeder links to a secondary status, and will impose arbitrary and one-sided constraints on their operation. INTELSAT's interpretation of RR 2613 is inconsistent with the detailed analysis of the impact of non-GSO MSS feeder links on GSO/FSS networks, especially when RBW is used. The Commission should adopt the approach to RR 2613 recommended by the NRM Negotiated Rulemaking Committee and proposed in the NPRM.

3.3 Specific Feeder Link Assignments

3.3.1 Introduction

The Commission is concerned that the 5150-5216 MHz band requested by several LEO/MSS applicants may not be available for LEO/MSS downlinks. The NRM report recommended consideration of frequencies below 15 GHz for feeder links. However, the NRM Committee did not conduct any feasibility analyses about which FSS allocations can indeed be considered by the Commission. Further, the Committee did not make any recommendations about the use of RBW concept in seeking and assigning LEO/MSS feeder links below 15 GHz.

The NPRM asks for comments on the use of specific FSS bands below 15 GHz (in FN119 of NPRM) for LEO/MSS feeder links. LQP believes that enough evidence exists to demonstrate that it is feasible to identify specific FSS spectrum blocks under 15 GHz for LEO/MSS feeder links where it can be shown that the feeder links can satisfactorily share the spectrum with both FSS and FS services. Such sharing may only require standard, well accepted, coordination procedures.

It is wise for the Commission to seek multiple feeder link spectrum blocks at C-, Ku-, and Ka-bands. The 20/30 GHz band may only satisfy the requirements of some of the LEO/MSS systems, particularly those of systems employing on-board processing and intersatellite links. Systems with design characteristics like GLOBALSTAR will indeed benefit from operation below 15 GHz. The economic and performance advantages of operating below 15 GHz cannot be ignored. Ka-band frequencies can pose problems in sharing feeder link spectrum, and in using dual-polarization. Ka-band polarization re-use is impractical due to the deplorization effects of rain on the signal, and will double the feeder link spectrum requirement, from 200 MHz to 400 MHz in each direction.

The use of large amount of spectrum in the Ku-band will preclude new Ka-band Fixed Satellite Services such as the system proposed by Teledesic. In addition, MSS feeder links in Ka-band will potentially create interference to Fixed Services such as Local Multi-Point Distribution Services (LMDS). Finally, the international usage of the Ka-band for terrestrial fixed and fixed-satellite-services is increasing.

Co-channel sharing of feeder links in the Ka-band is impractical due to the many satellites (208) potentially deployed. LQP has simulated the potential for conjunction of two or more satellites. Results show that this probability of conjunction is 6.3% of the time two satellites will be within 2 degrees of each other. The interval between conjunctions is between 0.07 minutes and 38 minutes. The average interval is 7 minutes. The duration of the conjunction is between 0.07 minutes and 1.4 minutes, with an average of 0.5 minutes.

3.3.2 Feeder Link Options Below 15 GHz

3.3.2.1 Introduction

If Reverse Band Working (RBW) is used for non-GSO MSS feeder links in the FSS allocations or the band currently assigned to aeronautical radionavigation, those feeder uplinks and downlinks will need to demonstrate that they can coexist with the existing terrestrial services in the same band.

Downlink interference has been analyzed and is acceptable, based on the low power-flux density of the MSS feeder downlinks.

Regarding LEO/MSS uplinks, the number of LEO/MSS feeder link stations to be deployed per system on a global basis is limited. Small countries will need only one gateway. Larger countries, like the U.S. may require more gateways. There is considerable flexibility in locating the gateway stations. Utilizing standard coordination procedures and proper siting, it is practical to operate the MSS uplinks without causing unacceptable interference to terrestrial services operating in this band.

The analyses presented in Section 3.2 demonstrate that the LEO/MSS and GSO/FSS systems can satisfactorily share the spectrum in the specific spectrum blocks discussed in this section. This section provides an analysis of the sharing feasibility of LEO/MSS feeder links with the terrestrial services operating in these bands The analysis is based on an extensive study conducted by Comsearch, Inc. utilizing its data-base of current terrestrial users in these bands. The Comsearch report is attached to this document as Attachment 12.

In selecting the specific FSS bands for study, the current utilization for FSS services was kept in mind. A detailed description of current usage situation in various FSS bands is provided in Document USTG 4/5-13: Fixed Satellite Service Frequency Allocations and Their Utilization, April 27, 1994.

3.3.2.2 Potential Bands for GLOBALSTAR Feeder Links

The requirement is to identify about 200 MHz in each spectrum block within FSS allocations for uplink or downlink operation of the LEO/MSS feeder links. Each LEO/MSS system requires about 200 MHz of spectrum in either direction. There are currently three applicants in the U.S. who have sought feeder link spectrum below 15

GHz. They all employ CDMA modulation. It is safe to assume that at least one spectrum pair (of 200 MHz bandwidth each) is required in C- and Ku-bands. It is also possible to assume a Ku-band uplink operating with a C-band downlink. This may be referred to as a hybrid-pair.

LEO/ MSS Feeder Uplink

a) 4500-4800 MHz Band

This is the planned FSS allotment band (App. 30B) for downlinks, and is largely unused. There are 53 entries and 4 satellite groups registered in this band. Government has co-primary allocations for fixed and mobile. Military mobile and fixed services operate in this band, and information is not available about the characteristics of the systems that are in use. Military uses include dual purpose line-of-sight/troposcatter links for tactical communications. These are point-to-point systems with sufficient power (greater than 1 KW) to allow troposcatter operations. In addition, the band is used in drone control, target scoring, and balloon-to-ground systems. The average bandwidth of fixed systems is 8 MHz. The military systems are utilized worldwide.

b) 5000-5250 MHz Band

The band is allocated to FSS by RR 797 if jointly used with aeronautical radionavigation or aeronautical mobile service under Article 14. In Europe, the band 5000-5150 MHz is used by aeronautical radionavigation (MLS). The band 5150-5250 was allocated to R-LANs, which offers sharing possibilities. The 5150-5216 MHz band was allocated to RDSS feeder link downlinks by RR 797A. The PFD is limited to -159 $dBW/m^2/4kHz$. This allocation is primary under Article 14 in certain countries of Regions 1 and 3 (as listed in RR 733B and 753C), primary in Region 2, and secondary elsewhere. Worldwide extension of the allocation is feasible consistent with compatibility studies with aeronautical radionavigation. Regarding terrestrial use of this band, Footnote 796 states that the band is to be used "for the operation of the international standard system MLS (microwave landing system) for precision approach and landing." Current plans for the MLS contemplate operations only in the 5030-5091 MHz portion of the band. Further, the aviation spokesmen at WARC-87 indicated that potential future expansion of MLS would not require frequencies above 5150 MHz. This band currently is under-utilized. The proposal is to use this band in RBW mode for LEO/MSS uplinks, with coordination with aviation facilities utilizing MLS systems, as required.

c) 6425-6725 MHz Band

This is the FSS extension band for uplink use. The LEO/MSS uplink will be operating co-directional with FSS systems. INTELSAT is expected to be a heavy user of this band, and the issue of coordination difficulties has been raised. There are currently 73 entries and 6 satellite systems registered in this band. The 6425-6525 MHz band is used by TV Pick-up in the U.S. The 6525-6625 MHz band is used by Operational Fixed Service (OFS) systems. The OFS use extends up to 6725 MHz. This band may be difficult for uplink use.

d) 10.7-10.95 GHz and 11.2-11.45 GHz Bands.

These are FSS allotment band identified for downlink use (Appendix 30B). There are 191 entries and 15 satellite systems registered in these bands. These bands are used by Common Carrier microwave systems in the United States. This band would use reverse band working (RBW), and may be feasible for MSS uplinks.

LEO/ MSS Feeder Downlink

a) 6525-6875 MHz Band

The 6525 -6650 MHz portion falls within the 6425-6650 MHz FSS uplink extension band. The 6650-6725 MHz portion falls within the FSS uplink allocation, and is not planned for use by INTELSAT. This sub-band has no corresponding FSS downlink allocation. The 6725-6875 MHz segment falls within the 6725-7025 MHz FSS planned uplink band governed by Appendix 30B, and is largely unused. There are 73 entries and 6 satellite systems registered in the 6425-6725 MHz segment of the band. The whole band (6525-6875 MHz) is used by Operational Fixed Services (OFS) on a co-primary basis. This band is feasible for downlinks.

b) 6875-7075 MHz Band

The 6825-7025 MHz portion falls within the 6725-7025 MHz planned FSS uplink allotment band (App. 30B), and is largely unused. The 7025-7075 MHz segment falls within the FSS uplink band and it is not planned for use by INTELSAT. There is no corresponding FSS downlink band. There are 32 entries and 4 satellite systems registered in the 6725-7025 MHz part of the band. There are 4 entries and 1 satellite system registered in the 7025-7075 MHz part of the band. The whole band (6875-7075 MHz) is used by auxiliary broadcast services (pt-to-pt, STL, ENG) on a co-primary basis. This band is feasible for downlinks and is LQP's preferred choice.

c) 12.75-13.25 GHz Band

This is the FSS allotment band for uplink use (App. 30B), and is largely unused. There are 25 entries and 3 satellite systems registered in this band. This band is shared on a co-primary basis by auxiliary broadcast services.

3.3.2.3 Sharing Analysis

The GLOBALSTAR (LEO-D) constellation and satellite parameters were used in conducting the sharing analysis of both uplink and downlink bands with the existing terrestrial users of each band.

In the first analysis, a simulation was conducted utilizing the software and methodology described in ITU-R Document 9D/Temp/31. It considered a 50-hop analogue microwave ITU-R typical system, and simulated interference into the reference microwave system from GLOBALSTAR feeder link downlink at 6.4 GHz. The simulation calculated time percentage of interference as a function of interference power (in picowatts) into the analogue system. Input PFD from GLOBALSTAR was considered to be -159 $dBW/m^2/4$ kHz for all angles of arrival for one case, and -159 for low angles/-152 for high angles for the second case. Both of these PFD inputs are considerably greater than LQP predicted actual values for its feeder downlinks. The results are plotted along with the specified (accepted) interference levels. The simulation applies statistical principles of Rec. 758 and Rec. 357 to analogue radio-relay systems.

The results are shown in Figure A-1. One will notice that there is at least 20 dB margin in the levels of interference. The calculated GLOBALSTAR feeder link downlink PFDs are around -170 at low angles and about -164 at high angles. The calculated PFD levels then provides an additional margin of 5 to 10 dB over the PFD levels used in the simulation, resulting in an overall performance margin of 25 to 30 dB. Even if one assumes that digital systems require additional protection of several dBs, there is still considerable protection margin according to the simulation.